

The millipedes and centipedes of Chiapas amber

Francisco Riquelme¹, Miguel Hernández-Patricio²

1 Laboratorio de Sistemática Molecular. Escuela de Estudios Superiores del Jicarero, Universidad Autónoma del Estado de Morelos, Jicarero C.P. 62909, Morelos, Mexico. **2** Subcoordinación de Inventarios Bióticos, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Tlalpan C.P. 14010, Mexico City, Mexico.

Corresponding author: Francisco Riquelme, francisco.riquelme@uaem.mx

Abstract

An inventory of fossil millipedes (class Diplopoda) and centipedes (class Chilopoda) from Miocene Chiapas amber, Mexico, is presented, with the inclusion of new records. For Diplopoda, 34 members are enumerated, for which 31 are described as new fossil records of the orders Siphonophorida Newport, 1844, Spirobolida Bollman, 1893, Polydesmida Leach, 1895, Stemmiulida Pocock, 1894, and the superorder Juliformia Attems, 1926. For Chilopoda 8 fossils are listed, for which 3 are new records of the order Geophilomorpha Pocock, 1895 and 2 are of the order Scolopendromorpha Pocock, 1895.

Key words

Miocene, Mexico, Diplopoda, Chilopoda.

Academic editor: Peter Dekker | Received 14 May 2018 | Accepted 26 July 2018 | Published 10 August 2018

Citation: Riquelme F, Hernández-Patricio F (2018) The millipedes and centipedes of Chiapas amber. Check List 14 (4): 637–646. <https://doi.org/10.15560/14.4.637>

Introduction

The extant species of millipedes and centipedes distributed across Mexico have been studied since the initial reports of Brand (1839) and Persbosc (1839). A current review of millipedes (Diplopoda) in Mexico was published by Bueno-Villegas et al. (2004) and reviews of centipedes (Chilopoda) were reported by Cupul-Magaña (2013) and Flores-Guerrero et al. (2015). The latter includes the fossil species *Scolopocryptops simojovelensis* Edgecombe et al. 2012 (Scolopendromorpha) from Chiapas Amber. Recently, the fossil millipedes *Parastemmiulus elektron* Riquelme, 2013 (Stemmiulida), *Anbarrhacus adamantis* Riquelme & Hernández-Patricio, 2014 (Polydesmida), and *Maatidesmus paachtun* Riquelme & Hernández-Patricio, 2014 (Polydesmida) from Chiapas amber (Riquelme et al. 2014a) were included in a new revision of

Diplopoda fossil record worldwide (Edgecombe 2015). Two other centipedes have been reported in Ross et al. (2016). Other records of millipedes have been mentioned in the literature but are questionable because of a lack of data and evidence (Hurd et al. 1962, Avendaño-Gil et al. 2012, Ross et al. 2016) or because specimens are not available (Hurd et al. 1962, Avendaño-Gil et al. 2012).

Excluding the probable millipede specimen *?Xylobius mexicanus* Müllerried 1942 from a upper Jurassic/mid-Cretaceous horizon in Puebla, Central Mexico, whose taxonomic identity is doubtful, the fossil material of both millipedes and centipedes in Mexico generally comes from the Miocene amber localities in the Chiapas Highlands in southwestern Mexico. These sites are part of the Chiapas amber Lagerstätte with remarkable fossil preservation of terrestrial arthropods, including myriapods (Riquelme et al. 2013, 2014a, b).

Here we address the current knowledge of fossil millipedes and centipedes in Miocene Chiapas amber. An inventory of fossil specimens is given, which mostly includes new fossil records (Table 1). Other records, as presented in published papers, are also mentioned. A major part of this work is the result of a short period of fieldwork and represents only an introductory account due to the difficulties surrounding the collection of fossil specimens. We estimate that in 2016 about 60 amber specimens of both millipedes and centipedes, but mostly millipedes, were found in the Chiapas amber area. But nearly 50 fossil specimens were lost in the same period due to commercial trading and smuggling. In the context of this loss of material, the present inventory of fossil specimens contributes significantly to the aim of estimating taxonomic diversity of both Diplopoda and Chilopoda in Mexico. It highlights new records of the order Siphonophorida, Spirobolida and Polydesmida in the Diplopoda and new records of the order Geophilomorpha and Scolopendromorpha in the Chilopoda.

Methods

A set of fossil specimens for this study was collected during 3 short field trips in 2015, 2016 and 2017 in the amber areas near the towns of Simojovel and Totolapa, Chiapas, Mexico. A second set of specimens was examined from the amber inclusion collection that belongs to the Museo del Ambar de Chiapas (MACH) and a third set of specimens was examined from the collection of the Museo del Ambar Lilia Mijangos (MALM), both located in San Cristobal de las Casas, Chiapas. The amber inclusion collections of these 2 museums are formally certified by the Instituto Nacional de Antropología e Historia (INAH), a federal agency that protects the paleontological heritage in Mexico. Exporting fossils from Mexico without INAH registration certificate is illegal under federal laws. Furthermore, 3 millipede specimens, currently lost by commercial trade, are also listed in this paper. These fossils were photographed and identified in the field using the informal code AM.CH., which in Spanish means Ámbar de Chiapas, followed by an identification number (Id).

Taxonomic treatment of each fossil specimen includes the extended version of the traditional Linnaean classification ranks. There is also morphological annotations and additional information of the current geographic distribution of closely related extant taxa in Mexico. Data from the 4 previously described fossil species are compiled from literature; however, the catalogue presented here is predominantly taxonomic, and not bibliographic. Terminology follows Enghoff et al. (2015) and Koch (2015) for the Diplopoda, and Bonato et al. (2011) for the Chilopoda. The microphotographs of the specimens were obtained by using multiple images stacking for 3-dimensional focus expansion in a Carl Zeiss microscope (Riquelme et al. 2014a, b).

List of collections acronyms is as follows:

AMNH: American Museum of Natural History, New York, USA.
CPAL-UAEM: Colección de Paleontología, Universidad Autónoma del Estado de Morelos, Morelos, Mexico.
IGL-UNAM: Colección Nacional de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Mexico City, Mexico.
MACH: Museo del Ámbar de Chiapas, San Cristóbal de las Casas, Chiapas, Mexico.
MALM: Museo del Ámbar Lilia Mijangos, San Cristóbal de las Casas, Chiapas, Mexico.
NMS: National Museum of Scotland, Edinburgh, Scotland.
SUCCINUM.INAH.2661: Private collection certified by the Instituto Nacional de Antropología e Historia (INAH), San Cristóbal de las Casas, Chiapas, Mexico.

Results

Millipedes

Class Diplopoda de Blainville in Gervais, 1844
Subclass Chilognata Latreille, 1802/1803
Infraclass Helminthomorpha Pocock, 1887
Subterclass Colobognatha Brandt, 1834
Order Siphonophorida Newport, 1844
Family Siphonophoridae Newport, 1844
Genus *Siphonophora* Brandt, 1837

Siphonophora sp. indet.

Referred material. 2 specimens: CPAL.102: adult male, complete specimen (Fig. 1A–C); MALM.21: adult of indeterminate sex, complete specimen.

Locality. Mexico, Chiapas: Simojovel: Guadalupe Victoria site, 17°07'58" N, 092°48'19" W.

Identification. Body slender and elongated; head without eyes, extended into a beak, antennae straight, wide and elongated, fully visible in CPAL.102 (Fig. 1A–C), trunk with about 44 rings in CPAL.102 and 72 in MALM.21, granulated dorsal sculpture in the metategite. Sex is indeterminable in MALM.21 by the position of the body. Both specimens represent the first fossil record of the family Siphonophoridae in Chiapas amber.

Remarks. Extant representatives of Siphonophorida in Mexico are currently found in the northern states of Sonora, Baja California Sur, Nuevo León, and Tamaulipas. They also found in the southern states of Veracruz and Yucatan (Bueno-Villegas et al. 2004).

Subterclass Eugnatha Attems, 1898
Superorder Juliformia Attems, 1926
Order Spirobolida Bollman, 1893

Spirobolida sp. indet.

Referred material. 2 specimens: MALM.313: adult of indeterminate sex, complete specimen (Fig. 1D–E); MALM.18: juvenile, complete specimen (Fig. 2A–C).

Locality. Mexico, Chiapas: Simojovel: La Pimienta site, 17° 08'29" N, 092°45'46" W.

Identification. Head with 18 or 11 ocelli, antenomeres short and flattened, collum smooth; trunk smooth with about 40 rings in MALM.313 or 28 as seen in MALM.18, telson with a preanal sclerite, two well-rounded valves and a short subanal plate. This is the first fossil record of Spirobolida in Chiapas amber.

Remarks. Living members of Spirobolida are found in 23 states of Mexico, including Baja California Sur, Baja California, Colima, Chiapas, Chihuahua, Durango, Guanajuato, Guerrero, Jalisco, Mexico City, Michoacán, Morelos, Nayarit, Nuevo León, Oaxaca, Puebla, Quintana Roo, San Luis Potosí, Tamaulipas, Veracruz, Yucatán, the State of Mexico, and Zacatecas (Bueno-Villegas et al. 2004, Shelley 2010, Medrano 2014).

Subterclass Eugnatha Attems, 1898
Superorder Juliformia Attems, 1926

Juliformia sp. indet.

Referred material. 1 specimen: MALM.306: adult of indeterminate sex, incomplete specimen (Fig. 3A, B).

Table 1. Diplopoda and Chilopoda from Chiapas amber, early-mid Miocene, Mexico.

Specimen	Order	Family, genus or species	Locality	Collection year	Repository
Diplopoda					
CPAL.101	Polydesmida	Platyrrhacidae	Simojovel, Guadalupe Victoria	2015	CPAL-UAEM
CPAL.102	Siphonophorida	<i>Siphonophora</i>	Simojovel, Guadalupe Victoria	2016	CPAL-UAEM
CPAL.103	Polydesmida		Simojovel, La Pimienta	2016	CPAL-UAEM
CPAL.104	Stemmiulida	Stemmiulidae	Simojovel, Guadalupe Victoria	2015	CPAL-UAEM
CPAL.105	Stemmiulida	Stemmiulidae	Simojovel, Guadalupe Victoria	2016	CPAL-UAEM
CPAL.106	Polydesmida		Simojovel, Guadalupe Victoria	2016	CPAL-UAEM
CPAL.107	Polydesmida		Simojovel, Guadalupe Victoria	2015	CPAL-UAEM
CPAL.108	Polydesmida		Totolapa, Rio Salado	2016	CPAL-UAEM
CPAL.109	Polydesmida	Xystodesmidae	Simojovel, Guadalupe Victoria	2016	CPAL-UAEM
CPAL.110	Polydesmida	Platyrrhacidae	Simojovel, Guadalupe Victoria	2016	CPAL-UAEM
CPAL.113	Polydesmida		Simojovel, La Pimienta	2016	CPAL-UAEM
CPAL.117	Polydesmida	<i>Myrmecodesmus</i>	Simojovel, Los Pocitos	2017	CPAL-UAEM
MACH21	Polydesmida		Simijovel, Los Pocitos	2014	MACH
MALM18	Spirobolida		Simojovel, La Pimienta	2015	MALM
MALM21	Siphonophorida	<i>Siphonophora</i>	Simojovel, Los Pocitos	2016	MALM
MALM28: holotype	Polydesmida	<i>Maatidesmus paachtun</i>	Simojovel, Guadalupe Victoria	2014	MALM
MALM301	Polydesmida		Simojovel, La Pimienta	2016	MALM
MALM302	Polydesmida		Simojovel, La Pimienta	2016	MALM
MALM303	Diplopoda		Simojovel, La Pimienta	2016	MALM
MALM304	Stemmiulida	Stemmiulidae	Simojovel, La Pimienta	2016	MALM
MALM305	Diplopoda		Simojovel, La Pimienta	2016	MALM
MALM306	Juliformia		Simojovel, La Pimienta	2016	MALM
MALM307	Polydesmida	Xystodesmidae	Simojovel, La Pimienta	2016	MALM
MALM308	Stemmiulida	Stemmiulidae	Simojovel, La Pimienta	2016	MALM
MALM309	Stemmiulida	Stemmiulidae	Simojovel, La Pimienta	2016	MALM
MALM310	Polydesmida		Simojovel, La Pimienta	2016	MALM
MALM311	Polydesmida		Simojovel, La Pimienta	2016	MALM
MALM312	Polydesmida		Simojovel, La Pimienta	2016	MALM
MALM313	Spirobolida		Simojovel, La Pimienta	2016	MALM
IGM 4544: holotype	Polydesmida	<i>Anbarrhacus adamantis</i>	Simojovel, Guadalupe Victoria	2014	IGL-UNAM
SUCCINUM.14: holotype	Stemmiulida	<i>Parastemmiulus elektron</i>	Simojovel, Guadalupe Victoria	2013	SUCCINUM. INAH.2661
AM.CH.ID33	Polydesmida	Chelodesmidae	Simojovel, Los Pocitos	2017	Specimen lost
AM.CH.ID34	Juliformia		Simojovel, Los Pocitos	2017	Specimen lost
AM.CH.ID35	Juliformia		Simojovel, Los Pocitos	2017	Specimen lost
Chilopoda					
CPAL.115	Scolopendromorpha	<i>Cryptops</i>	Simojovel, La Pimienta	2016	CPAL-UAEM
CPAL.116	Scolopendromorpha	<i>Cryptops</i>	Simojovel, El Porvenir	2017	CPAL-UAEM
MACH04	Geophilomorpha	<i>Polycricus</i>	Huitiupán	2013	MACH
MACH20	Geophilomorpha		Simojovel, La Pimienta	2015	MACH
MALM314	Geophilomorpha	<i>Polycricus</i>	Simojovel, La Pimienta	2016	MALM
AMNH Ch-SH7: holotype	Scolopendromorpha	<i>Scolopocryptops simojovelensis</i>	Simojovel?	?	AMNH
G.2014.50.2	Scutigermorpha		Simojovel?	?	NMS
G.2005.147.1.1	Geophilomorpha		Simojovel?	?	NMS

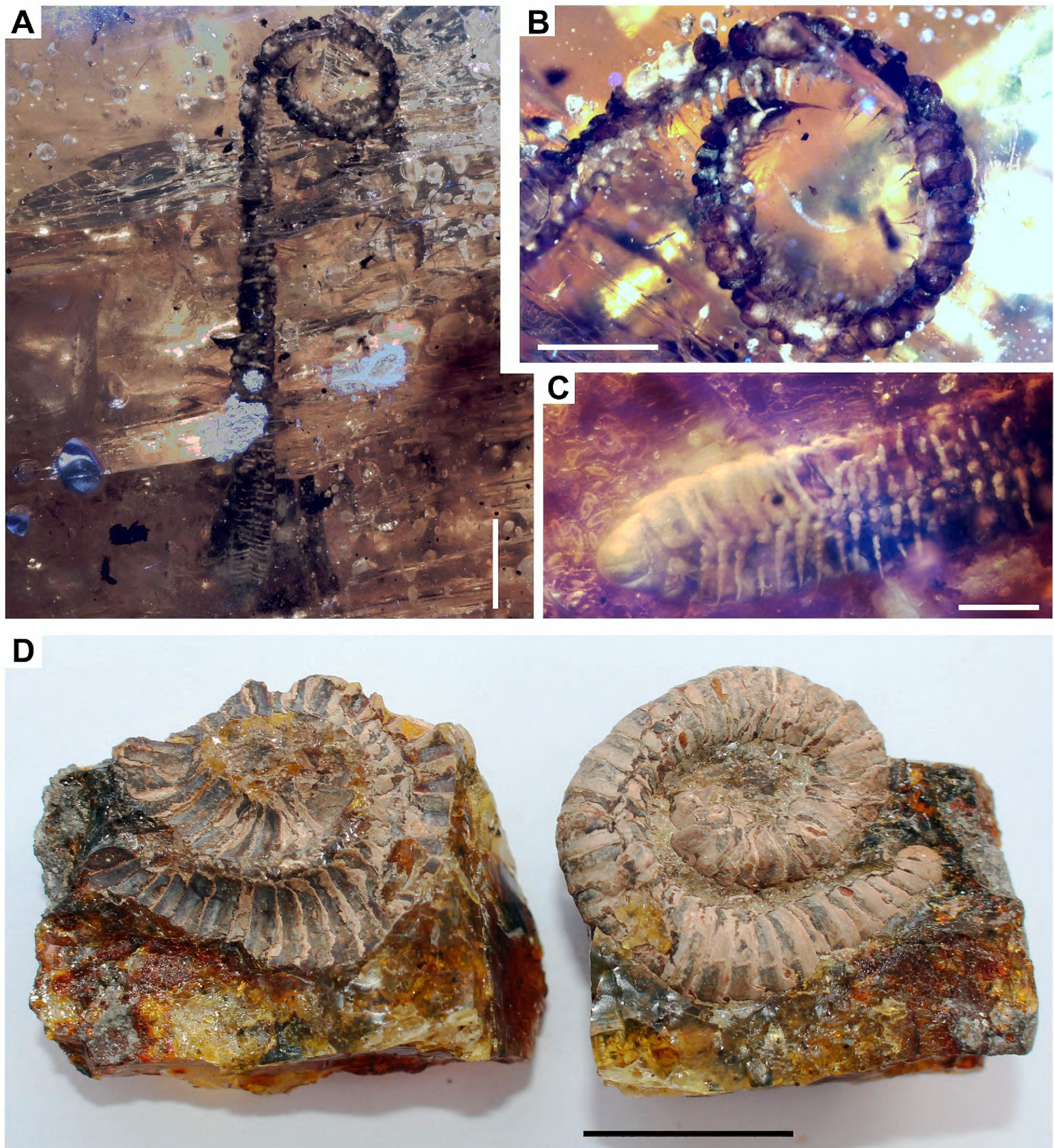


Figure 1. Millipedes from Simojovel, Chiapas, early-mid Miocene. **A–C.** CPAL.102, siphonophorid millipede; scale bars, A = 2 mm, B = 1 mm, C = 0.5 mm. **D.** MALM.3013, part A (left) and counterpart B (right), spirobolid millipede; scale bar = 20 mm.

Locality. Mexico, Chiapas: Simojovel: La Pimienta site, 17°08'29" N, 092°45'46" W.

Identification. Head partially lost, trunk smooth, body cylindrical and elongated that matches Juliformia, but the specimen is strongly damaged by the fossilization process, so no judgment is made as to its specific taxonomic position.

Remarks. The juliform millipedes are widely distributed in the Mexican territory (Bueno-Villegas et al. 2004, Shelley 2010, Medrano 2014, Cortés-Ríos and Gárate-Rodríguez 2017), but currently there are no records for Aguascalientes and Tlaxcala in Central Mexico.

Subterclass Eugnatha Attems, 1898
Superorder Merochaeta Cook, 1895
Order Polydesmida Leach, 1895

Polydesmida sp. indet.

Referred material. 11 specimens: MALM.301: juvenile (Fig. 3A, B), MALM.302: Juvenile (Fig 3A, B), MALM.310: adult of indeterminate sex (Fig. 3A, B); MALM.311 (Fig. 3A, B): Juvenile, MALM.312 (Fig. 3A, B): juvenile; CPAL.103: juvenile; CPAL.107: juvenile; CPAL.108: juvenile (Fig. 3F), CPAL.113: juvenile; CPAL.106: adult female; MACH.21: adult of indeterminate sex.

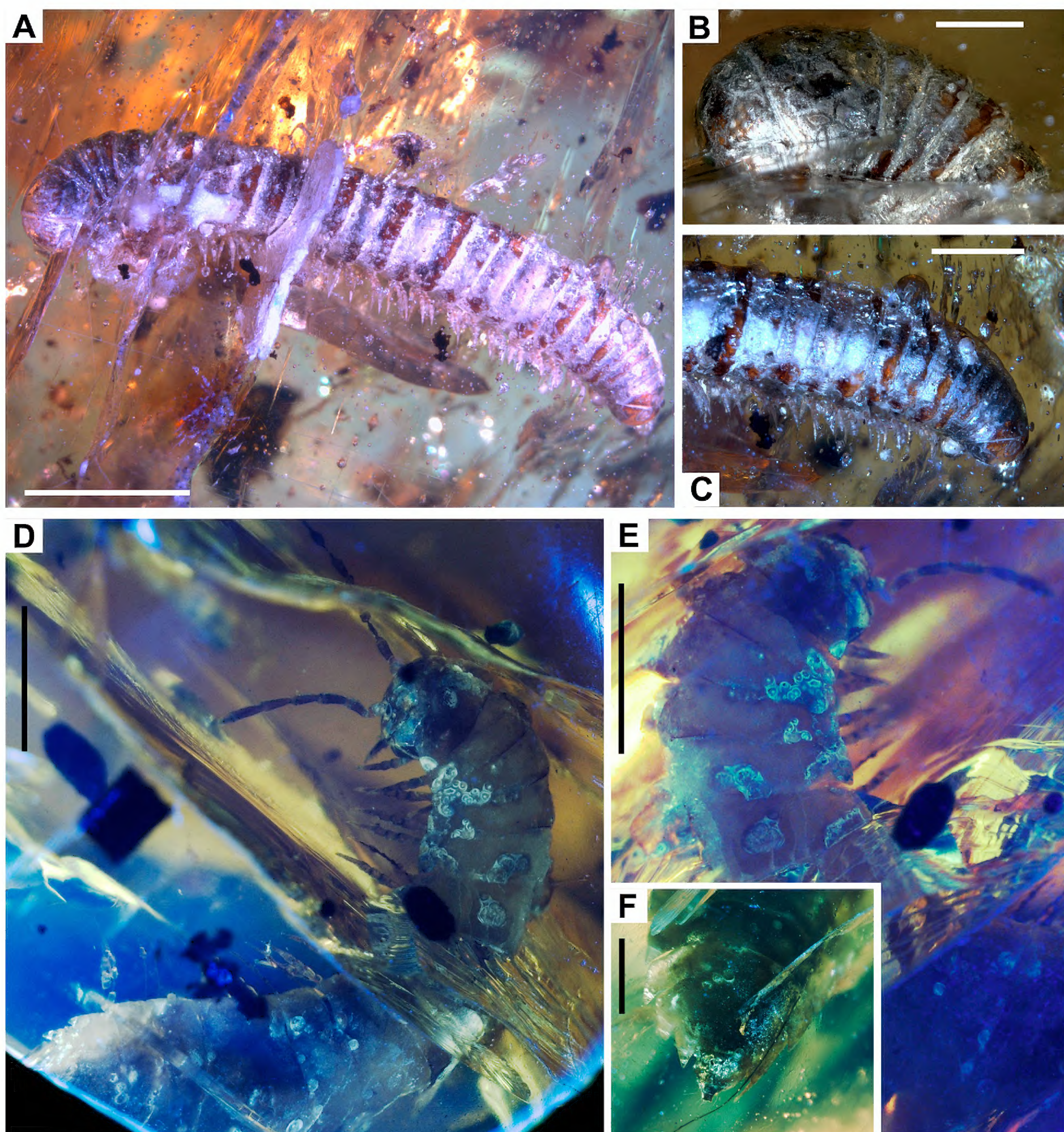


Figure 2. Millipedes from Simojovel, Chiapas, early-mid Miocene. **A–C.** MALM.18, spirobolid millipede; scale bars, A = 2 mm, B = 0.5 mm, C = 1 mm. **D–F.** CPAL.109, xystodesmid millipede; scale bars, A = 2 mm, E = 1 mm, F = 0.2 mm.

Locality. CPAL.103, CPAL.113, MALM.301, MALM.302, MALM.310, MALM.311, and MALM.312: Mexico, Chiapas: Simojovel: La Pimienta site, 17°08'29" N, 092°45'46" W. CPAL.106 and CPAL.107: Mexico, Chiapas, Simojovel, Guadalupe Victoria site, 17°07'58" N, 092°48'19" W. MACH.21: Mexico, Chiapas: Simojovel: Los Pocitos site, 17°08'18" N, 092°43'41" W. CPAL.108: Mexico, Chiapas: Totolapa: Río Salado site, 16°32'42" N, 092°40'58" W.

Identification. Head without eyes, antennae with 7 antennomeres plus 4 sensorial cones, labrum tridentate, body with 12 rings or less in immature specimens: CPAL.103, CPAL.107, CPAL.108, CPAL.113, MALM.301, MALM.302, MALM.311, and MALM.312, metazonite with short

lateral projections, CPAL.106 with 18 rings, MALM.310 with 20 rings, and MACH.21 with 20 rings, they are adult specimens but badly damaged, so no judgment is made as to their specific taxonomic position.

Order Polydesmida Leach, 1895

Suborder Leptodesmidea Brölemann, 1916

Superfamily Xystodesmoidea Cook, 1895

Family Xystodesmidae Cook, 1895

Xystodesmidae sp. indet.

Referred material. 2 specimens: CPAL.109: adult female, complete specimen (Fig. 2D–F); MALM.307: juvenile, complete specimen.

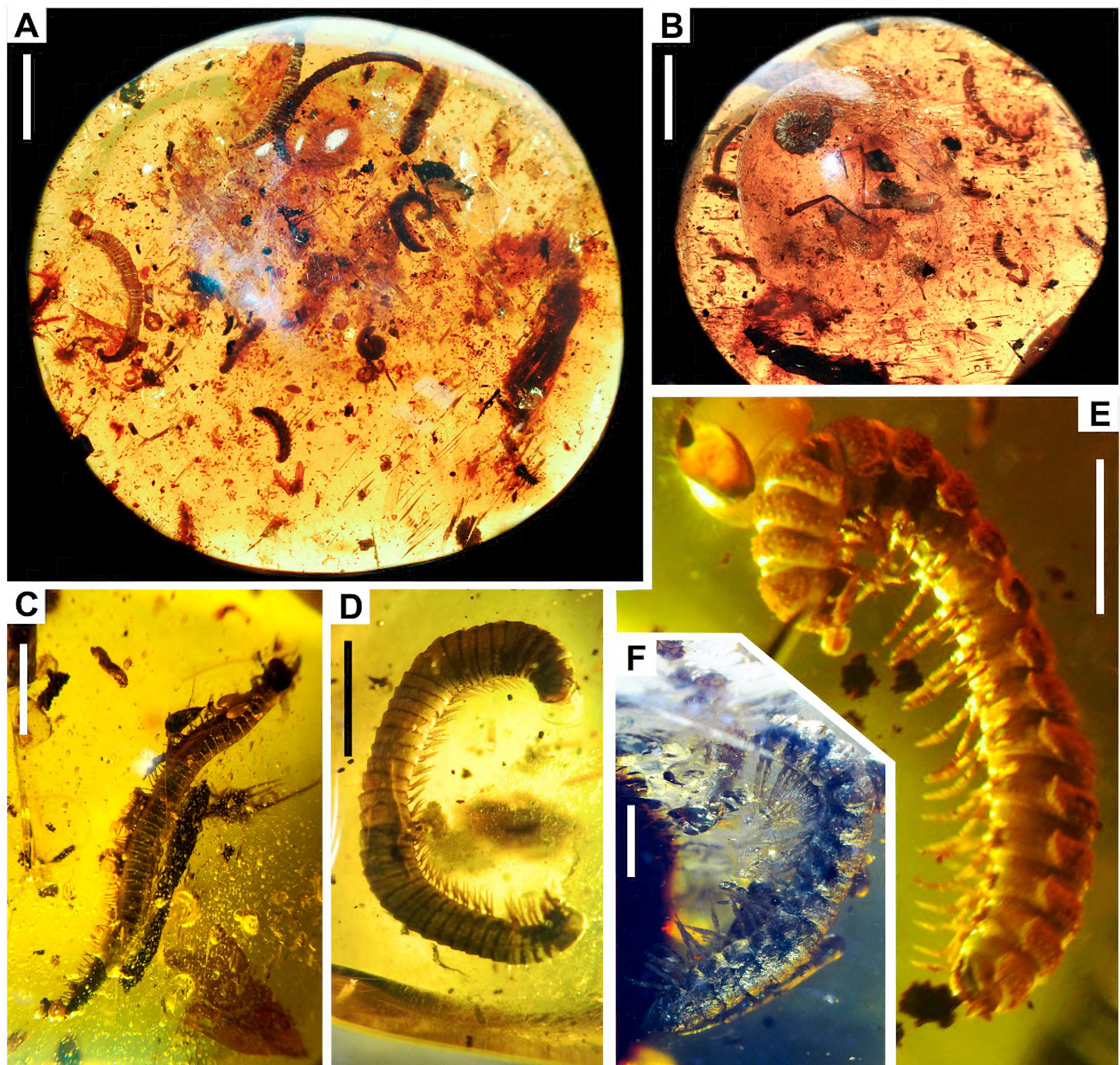


Figure 3. Millipedes from Simojovel, Chiapas, early-mid Miocene. **A.** Amber disc with 12 millipede specimens trapped inside, side A; scale bar = 10mm. **B.** Amber disc, side B; scale bar = 20 mm. Specimens from amber disc are as follows: MALM.301, MALM.302, MALM.303, MALM.304, MALM.305, MALM.306, MALM.307, MALM.308, MALM.309, MALM.310, MALM.311, and MALM.312. **C.** AM.CH.ID34, juliform millipede; scale bar = 5 mm. **D.** AM.CH.ID35, juliform millipede; scale bar = 5 mm. **E.** AM.CH.ID33, polydesmid millipede; scale bar = 5 mm. **F.** CPAL.108, polydesmid millipede; scale bar = 2 mm.

Locality. Mexico, Chiapas: Simojovel: Guadalupe Victoria site, 17°07'58" N, 092°48'19" W.

Identification. Body convex and tapering, head without eyes, antennae long and slender, collum smooth, trunk with about 17 rings in CPAL.109 and 20 in MALM.307, dorsally smooth, slightly mineralized in few zones by the fossilization process, paraterga subhorizontal, ozopores are fully visible on rings 5, 12, 13, and partially visible on rings 16, 17 and 18, as seen in a normal formula, epiproct conical with 2 short distal projections, and leg prefemura with short ventrodistal spine, which is clearly seen in the microscope, somewhat blurred in the micrograph due to the opacity of amber. Both specimens CPAL.109 and MALM.307 match Xystodesmidae, so this is the first fossil record of the family in Chiapas amber.

Remarks. The extant members of the family Xystodesmidae are recorded in 20 states from the north to the south of the country, including Coahuila, Chiapas, Guerrero, Guanajuato, Hidalgo, Jalisco, Mexico City, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, San Luis Potosí, Sinaloa, State of Mexico, Tabasco, Tamaulipas, Tlaxcala, Veracruz, and Yucatán (Bueno-Villegas et al. 2004, Cupul-Magaña et al. 2014, Cortés-Ríos and Gárate-Rodríguez 2017).

Superfamily Platyrrhacoidea Pocock, 1895

Family Platyrrhacidae Pocock, 1895

Platyrrhacidae sp. indet.

Referred material. 2 specimens: CPAL.101: adult female, complete specimen; CPAL.110: juvenile, complete specimen.

Locality. Mexico, Chiapas: Simojovel: La Pimienta site, 17°08'29" N, 092°45'46" W.

Identification. CPAL.101 with 19 rings, trunk broken, CPAL.110 with 17 rings, both match Platyrrhacidae. The extant representatives of Platyrrhacidae are found in the Neotropical region from the Antilles to Brazil (Shelley and Martinez-Torres 2013, Enghoff et al. 2015, among others).

Family Platyrrhacidae Pocock, 1895

Genus *Anbarrhacus* Riquelme & Hernández-Patricio, 2014

***Anbarrhacus adamantis* Riquelme & Hernández-Patricio in Riquelme et al., 2014**

Referred material. IGM 4544: holotype, juvenile, complete specimen.

Locality. Mexico, Chiapas: Simojovel: Guadalupe Victoria site, 17°07'58" N, 092°48'19" W.

Identification. Description in Riquelme et al. (2014a). There are no extant species of Platyrrhacidae currently recorded in Mexico (Enghoff et al. 2015).

Superfamily Chelodesmoidea Cook, 1895

Family Chelodesmidae Cook, 1895

Genus *Maatidesmus* Riquelme & Hernández-Patricio, 2014

***Maatidesmus paachtun* Riquelme & Hernández-Patricio in Riquelme et al., 2014**

Referred material. MALM.28: holotype, adult female, complete specimen.

Locality. Mexico, Chiapas: Simojovel: Guadalupe Victoria site, 17°07'58" N, 092°48'19" W.

Identification. Description in Riquelme et al. (2014a). The genus *Maatidesmus* is only known in the fossil record of Chiapas amber.

Remarks. Living members of the family Chelodesmidae are recorded at the southern states of Mexico, including Guerrero, Yucatán, Quintana Roo, Oaxaca, and Chiapas (Bueno-Villegas et al. 2004).

Order Polydesmida Leach, 1895

Suborder Polydesmidea Pocock, 1887

Superfamily Pyrgodesmoidea Silvestri, 1896

Family Pyrgodesmidae Silvestri, 1896

Genus *Myrmecodesmus* Silvestri, 1910

***Myrmecodesmus* sp. indet.**

Referred material. 1 specimen: CPAL.117: adult female, complete specimen.

Locality. Mexico, Chiapas: Simojovel: Los Pocitos site, 17°08'18" N, 092°43'41" W.

Identification. Head with vertex and frons roughened, antenna short, stout and clavate, collum with 10 lobes, body with 20 segments, paranota large, second ring with typical 3-lobed, and epiproct short and rounded. CPAL.117 matches *Myrmecodesmus* of the family Pyr-

godesmidae, representing the first record of this family in Chiapas amber.

Remarks. Extant species of the family Pyrgodesmidae are currently recorded in the Mexican states of Baja California Sur, Chiapas, Guerrero, Estado de México, Nuevo León, Oaxaca, Querétaro, San Luis Potosí, Tabasco, Tamaulipas, Veracruz and Yucatán (Hoffman 1999, Bueno-Villegas et al. 2004).

Superorder Nematophora Verhoeff, 1913

Order Stemmiulida Pocock, 1894

Family Stemmiulidae Pocock, 1894

Genus *Parastemmiulus* Riquelme, 2013

***Parastemmiulus elektron* Riquelme in Riquelme et al., 2013**

Referred material. SUCCINUM14.INAH.2661: holotype, adult male, complete specimen (see also Riquelme et al. 2013).

Locality. Mexico, Chiapas: Simojovel: Guadalupe Victoria site (= "La Guadalupe" of Riquelme et al. 2013), 17°07'58" N, 092°48'19" W.

Identification. Description as presented in Riquelme et al. (2013). The genus *Parastemmiulus* is only known in the fossil record of Chiapas amber.

Order Stemmiulida Pocock, 1894

Family Stemmiulidae Pocock, 1894

Stemmiulidae sp. indet.

Referred material. 5 specimens: CPAL.104: adult of indeterminate sex, complete specimen; CPAL.105: juvenile, complete specimen; MALM.304: adult of indeterminate sex, complete specimen; MALM.308: adult of indeterminate sex, complete specimen; MALM.309: adult of indeterminate sex, complete specimen (Fig. 3A, B).

Locality. Mexico, Chiapas: Simojovel: Guadalupe Victoria site, 17°07'58" N, 092°48'19" W.

Identification. Head partially damaged or not fully visible in CPAL.104, body cylindrical, 2 apodous segments before telson, tergites with a longitudinal groove, ozopore present, legs long, telson short, epiproct minute, a pair of stout paraprocts with setae along the anal opening is also present. All fossil specimens match Stemmiulida, but for more specific taxonomic position they need further revision.

Remarks. Extant species of Stemmiulida are recorded almost exclusively at the southern region of Mexico, including the states of Veracruz, Campeche and Quintana Roo (Bueno-Villegas et al. 2004).

Millipedes preliminary identified but not determined

Class Diplopoda de Blainville in Gervais, 1844

Diplopoda sp. indet.

Referred material. 2 complete specimens: MALM.303 and MALM.305.

Locality. Mexico, Chiapas: Simojovel: La Pimienta site, 17°08'29" N, 092°45'46" W.

Identification. Two specimens surrounded by other millipede specimens within the same disc-shaped piece of amber (Figure 2A-B), which does not allow a more accurate description of their anatomy at the present.

Millipedes preliminary identified but currently lost

Subterclass Eugnatha Attems, 1898

Superorder Juliformia Attems, 1926

Referred material. 2 complete specimens: AM.CH.Id34 and AM.CH.Id35: adults of undetermined sex, lost by commercial trade (Fig. 3C, D)

Locality. Mexico, Chiapas: Simojovel: Los Pocitos site, 17°08'18" N, 092°43'41" W.

Identification. The fossils specimens were observed in the field, body and general appearance matches juliform millipedes. These fossils were sold days after their discovery, so no judgment is made as to their taxonomic position.

Order Polydesmida Leach, 1895

Referred material. 1 specimen: AM.CH.Id33: adult of undetermined sex, complete specimen, lost by commercial trade (Fig. 3E).

Locality. Mexico, Chiapas: Simojovel: Los Pocitos site, 17°08'18" N, 092°43'41" W.

Identification. This fossil specimen was observed in the field, it seems closely related with the extant representatives of the Family Chelodesmidae, particularly with the fossil species *M. paachtun* as described in Riquelme et al. (2014a).

Centipedes

Class Chilopoda Latreille, 1817

Subclass Pleurostigmophora Verhoeff, 1901

Order Geophilomorpha Pocock, 1895

Family Geophilidae Leach, 1815

Genus *Polycricus* Saussure & Humbert, 1872

Polycricus sp. indet.

Referred material. 2 specimens: MACH.4: adult of undetermined sex, incomplete specimen; MALM.314: adult of undetermined sex, incomplete specimen (Fig. 4A–D).

Locality. MACH.4: Mexico, Chiapas: Huitiupán, 17°10'13" N, 092°41'24" W. MALM.314: Mexico, Chiapas: Simojovel: La Pimienta site, 17°08'29" N, 092°45'46" W.

Identification. MACH.4 body with 30 pairs of legs and MALM.314 with 31, both without distal segment, head moderately elongated, antennae slender with 14 segments, forcipular segment elongated and broad; the 2 specimens match the genus *Polycricus*. A published study of molecular taphonomy, which includes the MACH.4

sample, shows an infrared micrograph of the specimen (Riquelme et al. 2014b:10, fig. 7). This represents the first record of the family Geophilidae in Chiapas amber.

Remarks. Extant members of the family Geophilidae are recorded in northern and central Mexico, including the states of Baja California Sur, Guerrero, Hidalgo, Mexico City, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, Sinaloa, State of Mexico, Tamaulipas and Veracruz (Cupul-Magaña 2013, Flores-Guerrero et al. 2015).

Order Scolopendromorpha Pocock, 1895

Family Scolopocryptopidae Pocock, 1896

Genus *Scolopocryptops* Newport, 1844

Scolopocryptops simojovelensis Edgecombe, Vahtera, Stock, Kallonen, Xiao, Rack & Giribet in Edgecombe et al., 2012

Referred material. AMNH Ch-SH7, holotype, as seen in Edgecombe et al. (2012).

Locality. Mexico, Chiapas: Simojovel area. Edgecombe et al. (2012) provided no data about the exact locality.

Identification. Description as presented in Edgecombe et al. (2012).

Remarks. The living species of *Scolopocryptops* are recorded in 10 states of Mexico, including Baja California, Chiapas, Guerrero, Morelos, Nayarit, Oaxaca, Puebla, Querétaro, San Luis Potosí and Veracruz (Shelley 2002, Cupul-Magaña 2013, Flores-Guerrero et al. 2015).

Family Cryptopidae Kohlrausch, 1881

Genus *Cryptops* Leach, 1815

Cryptops sp. indet.

Referred material: 2 specimens: CPAL.115: complete specimen, adult of undetermined sex. CPAL.116: complete specimen, adult of undetermined sex.

Locality. CPAL.115: Mexico, Chiapas, Simojovel, La Pimienta site, 17°08'29" N, 092°45'46" W. CPAL.116: Mexico, Chiapas, Simojovel, El Porvenir site, 17°09'10" N, 092°44'21" W.

Identification. Head without ocelli, antennae with 17 segments, body slender, with 21 segments, both specimens match the genus *Cryptops*. This is the first record of the genus in Chiapas amber.

Remarks. The living species of *Cryptops* are currently recorded in the states of Guerrero, Jalisco and Veracruz (Cupul-Magaña 2013).

Centipedes preliminary identified but not determined

Order Geophilomorpha Pocock, 1895

Referred material. 1 specimen: MACH.20: adult of undetermined sex, incomplete specimen.

Locality. MACH.20: Mexico, Chiapas, Simojovel, La Pimienta site, 17°08'29" N, 092°45'46" W.

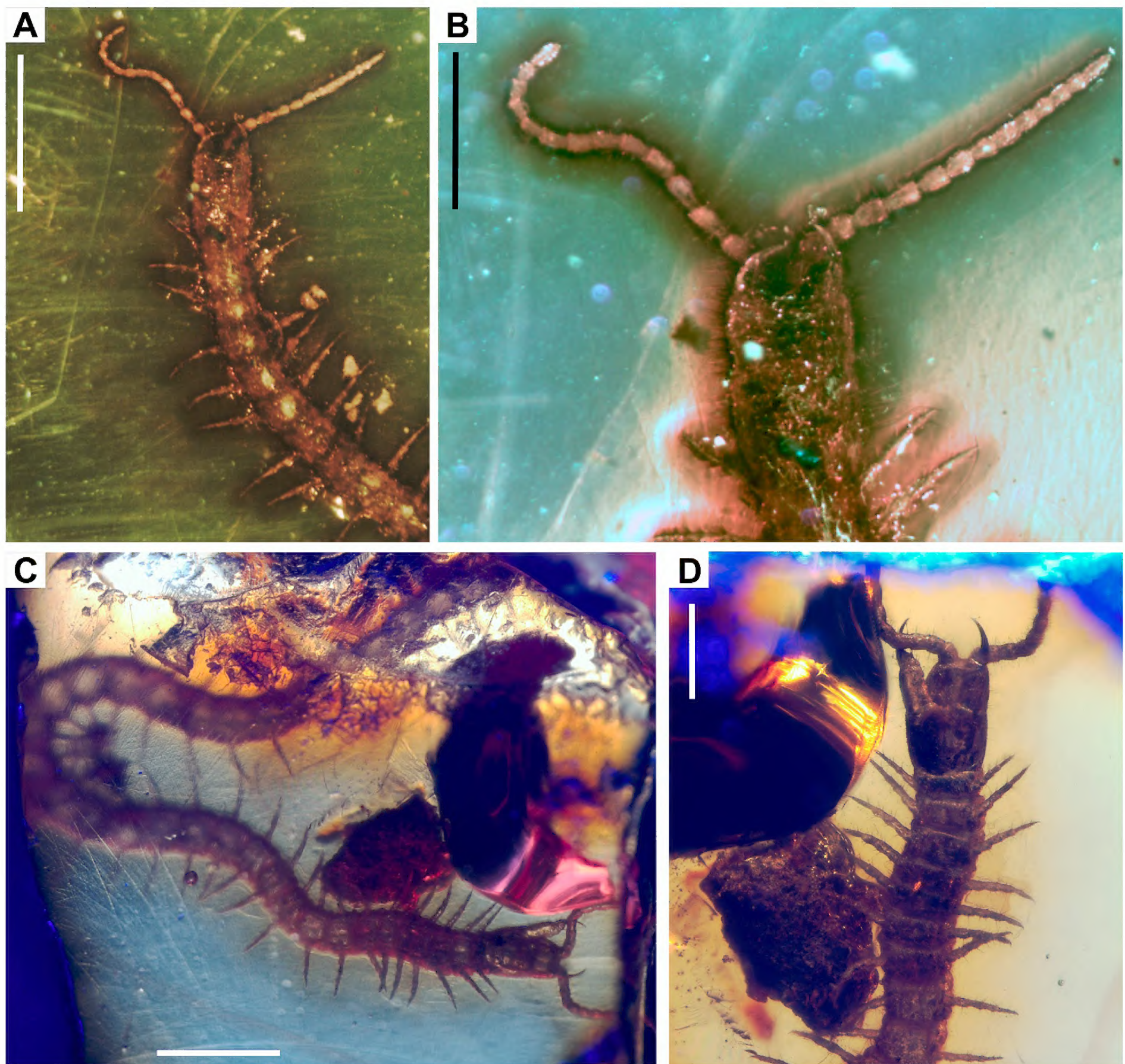


Figure 4. Centipedes from Simojovel, Chiapas, early-mid Miocene. (A-B): MACH.4, geophilomorph centipede from Huitiupán, Chiapas, early-mid Miocene (scale bar A: 2mm, B: 1mm). (C-D): MALM.314: geophilomorph centipede from Simojovel, Chiapas, early-mid Miocene (scale bar C: 1 mm, D: 0.5 mm).

Identification. MACH.20 without head or terminal segments, body with more than 40 pairs of legs; fossil specimen match Geophilomorpha but this shows poor preservation that makes a more detailed description difficult.

Referred material. 1 specimen: G.2005.147.1.1, as seen in Ross et al. (2016: 46, fig. 2).

Locality. Mexico, Chiapas? Simojovel area? The origin of this material is unproven; there are no data about the exact locality or strata provided by Ross et al. (2016).

Remarks. Specimen undetermined; micrograph published in Ross et al. (2016). Accordingly, the specimens resemble Geophilomorpha. Ross et al. (2016) also referred to another geophilomorph specimen, which they identified as G.2007.67.10.1 (Ross and Sheridan 2013: 55, fig. 9), but this is the same specimen G.2005.147.1.1 (even the same photo) as presented in Ross et al. (2016: 46, fig. 2).

Order Scutigermorpha Pocock, 1895

Referred material. 1 specimen: G.2014.50.2, as seen in Ross et al. (2016: 47, fig. 3).

Locality. Mexico, Chiapas? Simojovel area? The origin of this material is unproven; there is no data about the exact locality or strata provided by Ross et al. (2016).

Remarks. Specimen undetermined, according to micrographs published in Ross et al. (2016), the specimen resembles Scutigermorpha.

Discussion

It is not possible to check the identity of *?Xylobius mexicanus* because the fossil specimen is currently missing (Müllerried 1942). Its geological age is also uncertain. In the absence of the specimen and additional evidence (no images were found), it is reasonable to consider it as

a highly doubtful record. Currently the fossil record of Mexico confidently assignable to Diplopoda and Chilopoda is limited to the mid-Cenozoic of Chiapas (Table 1); for Diplopoda this includes 4 orders, 6 families, 5 genera and 3 species; whereas for Chilopoda this comprises 3 orders, 3 families, 3 genera and 1 species.

Acknowledgements

We thank Luis Zúñiga for access to the fossil collection at the MALM. We also thank Bibiano Luna for the access to the MACH. We thank Susana Guzmán at the Instituto de Biología, UNAM, for assistance with photomicrography, and Jon D. Richey at the University of California, Davis, for English editing. We also thank the Academic editor Peter Decker, Fabio Cupul, Julian Bueno-Villegas, and another anonymous reviewer whose feedback has improved the final published version.

Authors' Contributions

FR and MHP collected and identified the fossil material; FR wrote the text.

References

- Avendaño-Gil J, Carbot-Chanona G, Coutiño-José MA (2012) Estudio del ámbar con inclusiones biológicas de la Colección Paleontológica de la Secretaría de Medio Ambiente e Historia Natural, Chiapas, México. *Lacandonia* 6 (1): 23–29.
- Bonato L, Edgecombe GD, Zapparoli M (2011) Chilopoda—taxonomic overview. In: Minelli A (Ed) *Treatise on Zoology—Anatomy, Taxonomy, Biology. The Myriapoda*, Vol. 1. Brill, Netherlands, 363–443. <https://doi.org/10.1163/9789004188273>
- Brant M (1839) Note relative a la classification des espèces qui composent le genre *Polydesmus*, et suivie d'une caractéristique de dix espèces nouvelles, ainsi que de quelques remarques sur la distribution géographique des espèces en général. *Bulletin de l'Académie impériale des sciences de St.-Petersbourg* 8: 94–103.
- Bueno-Villegas J, Sierwald P, Bond JE (2004) Diplopoda. In: Llorente-Bousquets J, Morrone JJ, Yáñez-Ordóñez O, Vargas-Fernández I (Eds) *Biodiversidad, Taxonomía y Biogeografía de los Artrópodos de México: Hacia una síntesis de su conocimiento*, Vol. 4. CONABIO-UNAM, México, 569–599.
- Cortés-Ríos BE, Gárate-Rodríguez JD (2017) Diversidad biológica de ciempiés en Surutato, Badiraguato, Sinaloa. *Boletín de Sociedad Mexicana de Entomología (N. S.)* 3: 23–26.
- Cupul-Magaña FG (2013) La diversidad de los ciempiés (Chilopoda) de México. *Dugesiana* 20 (1): 17–41.
- Cupul-Magaña FG, Vargas MDRV, Bueno-Villegas J, Shelley RM (2014) Notas sobre los miriápodos (Arthropoda: Myriapoda) de Jalisco, México: Distribución y nuevos registros. *Dugesiana* 21 (2): 83–97.
- Edgecombe GD, Vahtera V, Stock SR, Kallonen AP, Xiao X, Rack A, Giribet G (2012) A scolopocryptopid centipede (Chilopoda: Scolopendromorpha) from Mexican amber: synchrotron microtomography and phylogenetic placement using a combined morphological and molecular dataset. *Zoological Journal of the Linnean Society* 166 (4): 768–786. <https://doi.org/10.1111/j.1096-3642.2012.00860.x>
- Edgecombe GD (2015) Diplopoda—Fossils. In: Minelli A (Ed) *Treatise on Zoology—Anatomy, Taxonomy, Biology. The Myriapoda*, Vol. 2. Brill, Netherlands, 337–351. <https://doi.org/10.1163/9789004188273>
- Enghoff H, Golovatch S, Short M, Stoev P, Wesener T (2015) Diplopoda: taxonomic overview. In: Minelli A (Ed) *Treatise on Zoology—Anatomy, Taxonomy, Biology. The Myriapoda*, Vol. 2. Brill, Netherlands, 363–453. <https://doi.org/10.1163/9789004188273>
- Flores-Guerrero U, Cupul-Magaña FG, Bueno-Villegas J, Rodríguez-López E (2015) Adenda y corrigenda de *Dugesiana* 20 (1): 17–41, La diversidad de los ciempiés (Chilopoda) de México. *Dugesiana* 22: 69–80.
- Hoffman RL (1999) Checklist of the millipeds of North and Middle America. *Virginia Museum of Natural History Special Publication* 8: 1–584.
- Hurd PD, JR, Smith RF, Durham JW (1962) The fossiliferous amber of Chiapas, México. *Ciencia* 21: 107–118.
- Koch M (2015) Diplopoda—general morphology. In: Minelli A (Ed) *Treatise on Zoology—Anatomy, Taxonomy, Biology. The Myriapoda*, Vol. 2. Brill, Netherlands, 7–67. <https://doi.org/10.1163/9789004188273>
- Medrano M (2014) A morphological phylogenetic analysis and taxonomic revision of the millipede family Atopetholidae (Chamberlin) (Diplopoda: Spirobolida) with descriptions of new species and the conservation status of *Comanchelus chihuensis* (Chamberlin 1947) (Diplopoda: Spirobolida: Atopetholidae), a species of concern. Doctoral dissertation, University of New Mexico, Albuquerque, New Mexico, USA, 435 pp.
- Müllerried FKG (1942) Fósiles raros de México I. El primer miriápodo fósil de México, encontrado en el estado de Puebla. *Anales del Instituto de Biología* 13: 711–717.
- Perbosc M (1839) Insectes nouveaux découverts au Mexique. *Revue Zoologique par la Société Cuvierienne* 2: 261–264.
- Riquelme F, Alvarado-Ortega J, Ramos-Arias M, Hernández M, Le Dez I, Lee-Whiting TA, Ruvalcaba-Sil JL (2013) A fossil stemmiulid millipede (Diplopoda: Stemmiulida) from the Miocene amber of Simojovel, Chiapas, Mexico. *Historical Biology* 26 (4): 415–427. <https://doi.org/10.1080/08912963.2013.778843>
- Riquelme F, Alvarado-Ortega J, Ramos-Arias M, Hernández M, Le Dez I, Lee-Whiting TA, Ruvalcaba-Sil JL (2013) Historical Biology: Corrigendum. <https://doi.org/10.1080/08912963.2013.824264>
- Riquelme F, Hernández-Patricio M, Martínez-Dávalos A, Rodríguez-Villafuerte M, Montejó-Cruz M, Alvarado-Ortega J, Ruvalcaba-Sil JL, Zúñiga-Mijangos L (2014a) Two flat-backed polydesmidan millipedes from the Miocene Chiapas-Amber Lagerstätte, Mexico. *PLoS ONE* 9 (8): e105877. <https://doi.org/10.1371/journal.pone.0105877>
- Riquelme F, Northrup P, Ruvalcaba-Sil JL, Stojanoff V, Siddons DP, Alvarado-Ortega J (2014b) Insights into molecular chemistry of Chiapas amber using infrared-light microscopy, PIXE/RBS, and sulfur K-edge XANES spectroscopy. *Applied Physics A* 116: 97–109. <https://doi.org/10.1007/s00339-013-8185-2>
- Ross AJ, Sheridan A (2013) *Amazing Amber*. National Museums Scotland Enterprises, Edinburgh, 64 pp.
- Ross AJ, Mellish CJ, Crighton B, York PV (2016) A catalogue of the collections of Mexican amber at the Natural History Museum, London and National Museums Scotland, Edinburgh, UK. *Boletín de la Sociedad Geológica Mexicana* 68 (1): 45–55. <https://doi.org/10.18268/BSGM2016v68n1a7>
- Shelley RM (2002) A synopsis of the North American centipedes of the order Scolopendromorpha (Chilopoda). *Virginia Museum of Natural History Memoir* 5: 1–108.
- Shelley RM (2010) Occurrence of the milliped, *Hiltonius carpinus carpinus* Chamberlin, 1943 (Spirobolida: Spirobolidae), in the United States and new records from Mexico. *Insecta Mundi* 0116: 1–3.
- Shelley RM, Martínez-Torres D (2013) The milliped family Platyrhacidae (Polydesmida: Leptodesmidea) in the West Indies: proposal of *Hoffmanorhacus* n. gen.; description and illustrations of males of *Proaspis aitia* Loomis, 1941; redescription of *Nannorhacus luciae* (Pocock, 1894); hypotheses on origins and affinities; and an updated New World familial distribution. *Zootaxa* 3626: 477–498. <https://doi.org/10.11646/zootaxa.3626.4.4>